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Furukawa

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(54) **LIQUID EJECTION HEAD AND METHOD FOR FABRICATING THE SAME**

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B41J 2/145 (2006.01)
B41J 2/16 (2006.01)

(52) **U.S. Cl.**
CPC .. ***B41J 2/145*** (2013.01); ***B41J 2/16*** (2013.01); ***B41J 2/1603*** (2013.01); ***B41J 2/1623*** (2013.01); ***B41J 2/1632*** (2013.01); *Y10T 29/49401* (2015.01)

(58) **Field of Classification Search**
CPC B41J 29/393; B41J 29/38; B41J 29/02; B41J 11/42; B41J 2/04505; B41J 13/02
See application file for complete search history.

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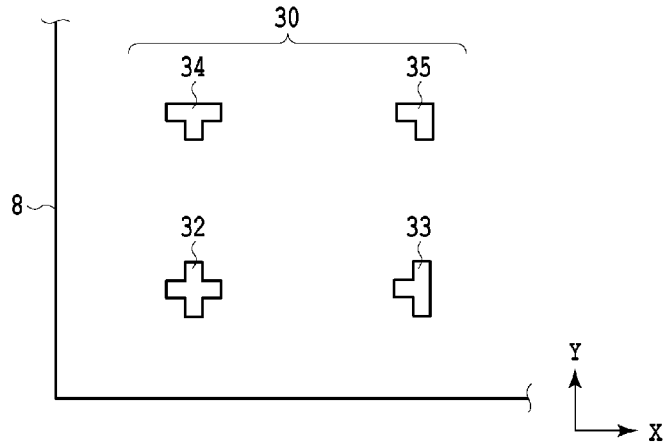
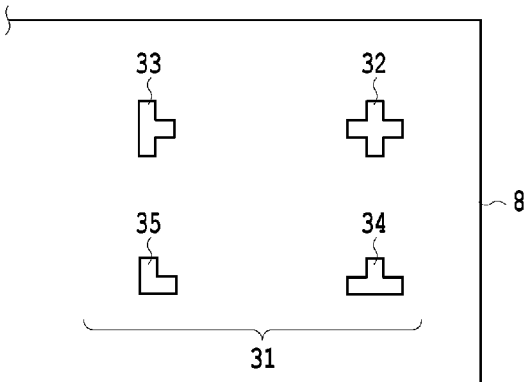
(74) *Attorney, Agent, or Firm* — Fitzpatrick, Cella, Harper & Scinto

(57) **ABSTRACT**

There is provided a liquid ejection head that can reduce trouble in alignment of a print element substrate even in the case where a high magnification optical system is used and a method for fabricating the liquid ejection head. To achieve this, an auxiliary mark that indicates a relative position with respect to a reference mark is detected and recognized, and thus the position of the reference mark is identified even in the case where the reference mark is not reflected in a camera.

19 Claims, 12 Drawing Sheets





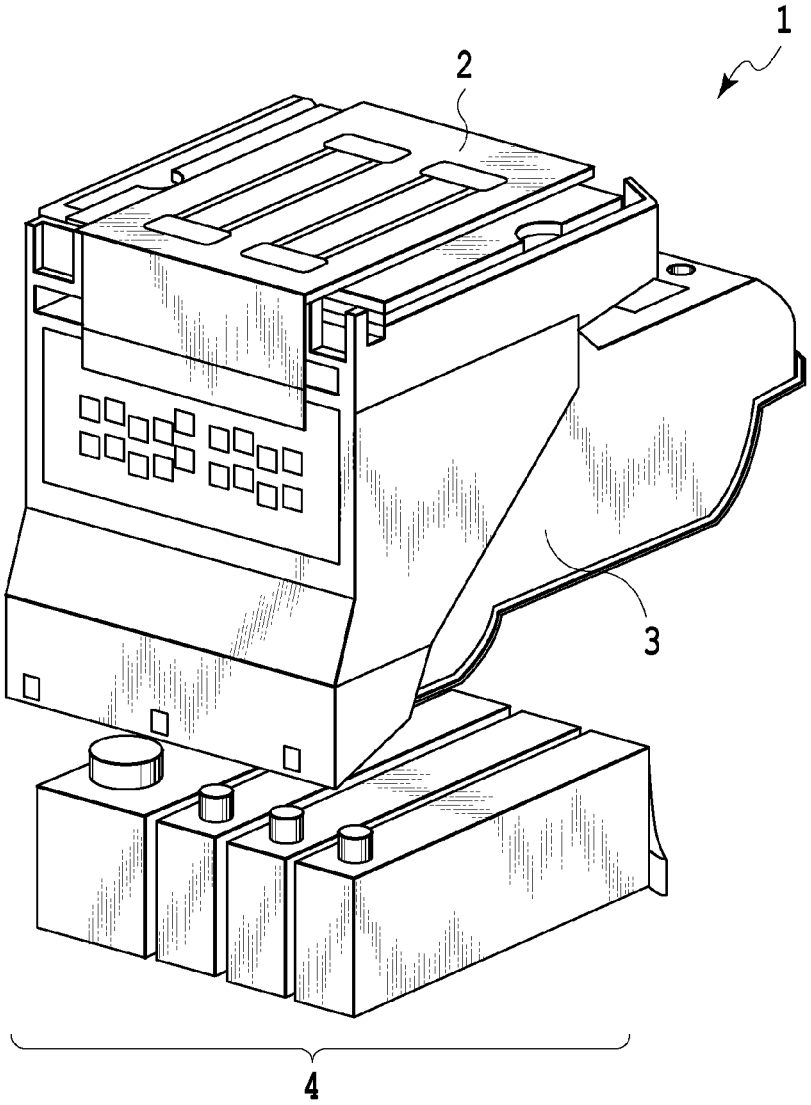


FIG.1

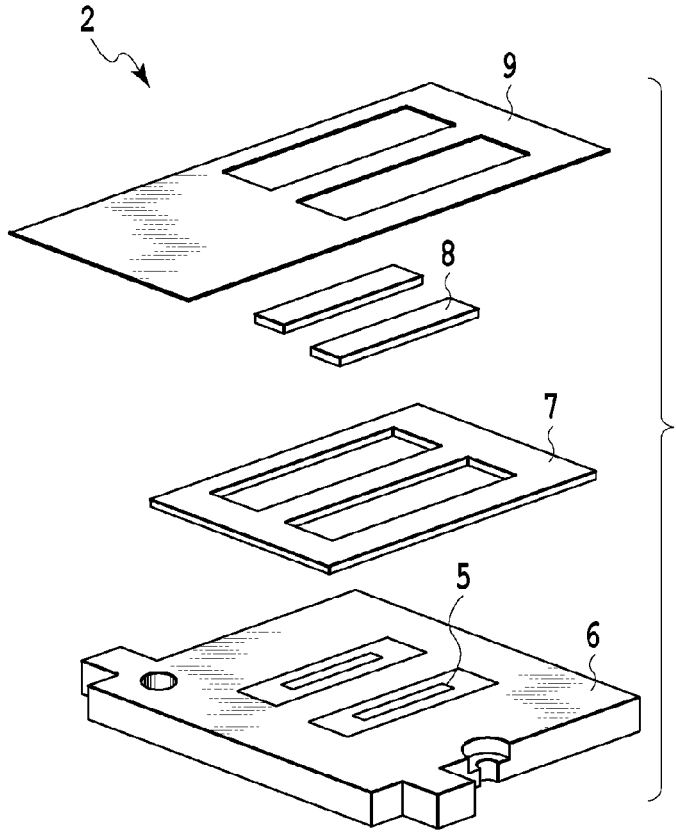


FIG.2A

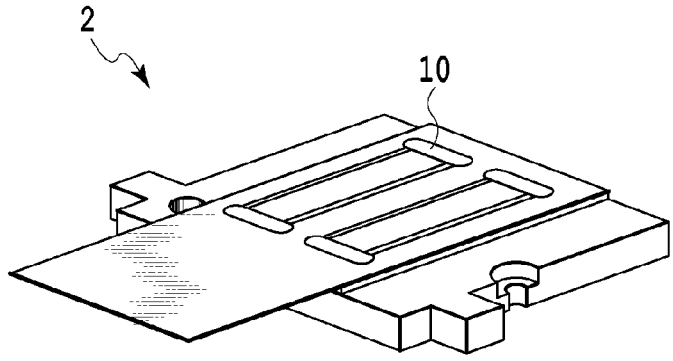


FIG.2B

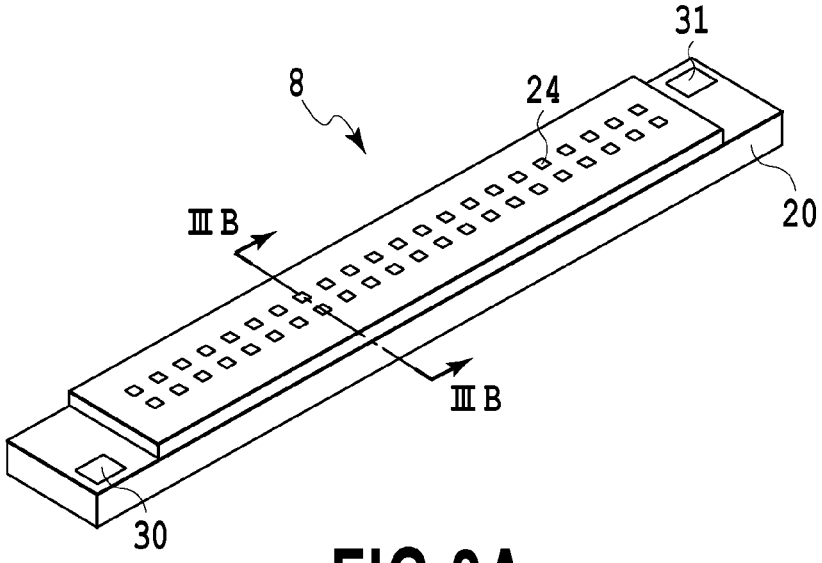


FIG.3A

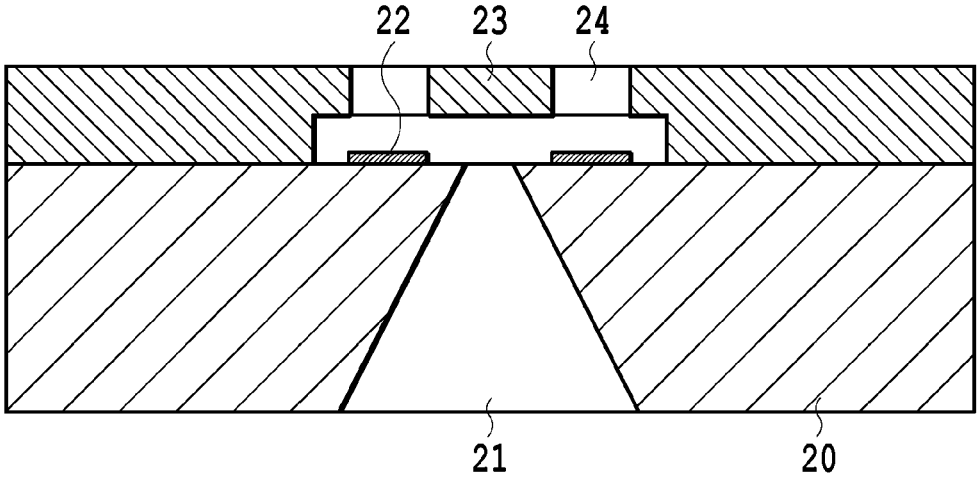


FIG.3B

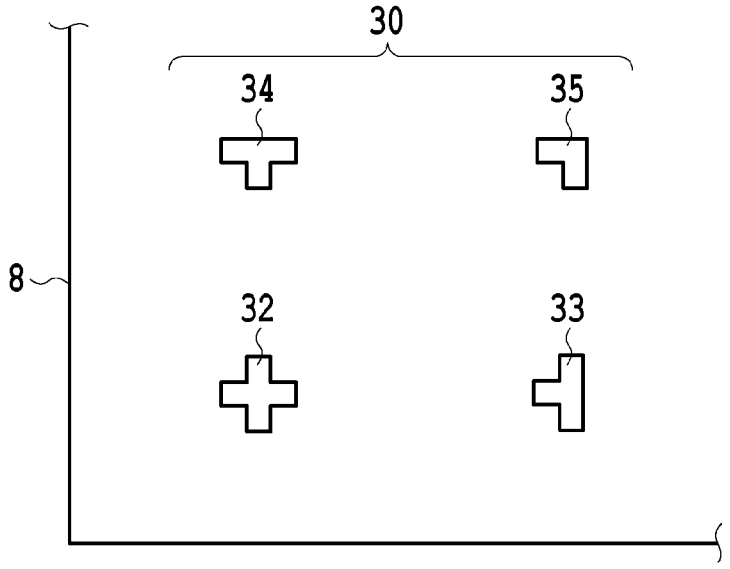


FIG.4A

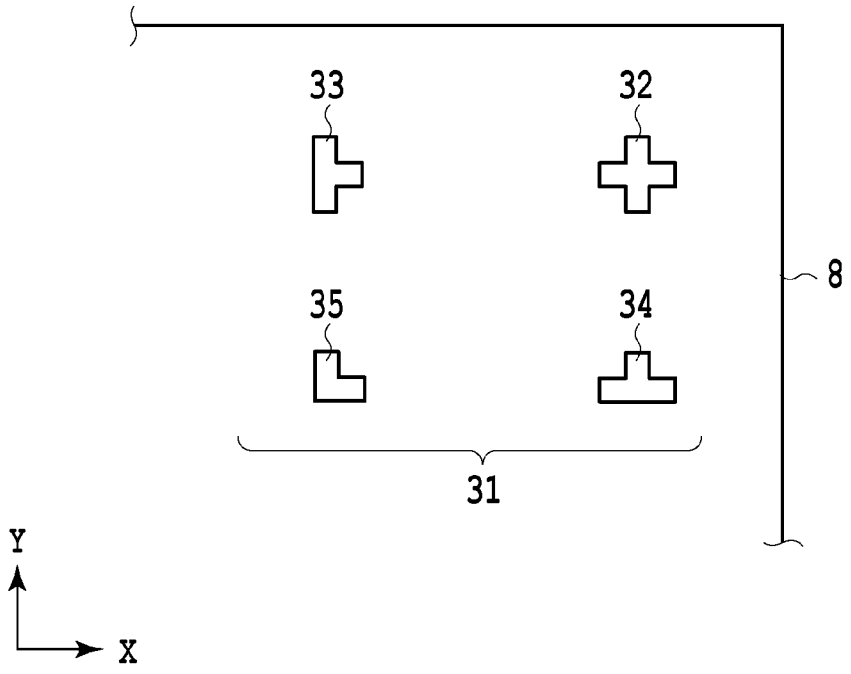


FIG.4B

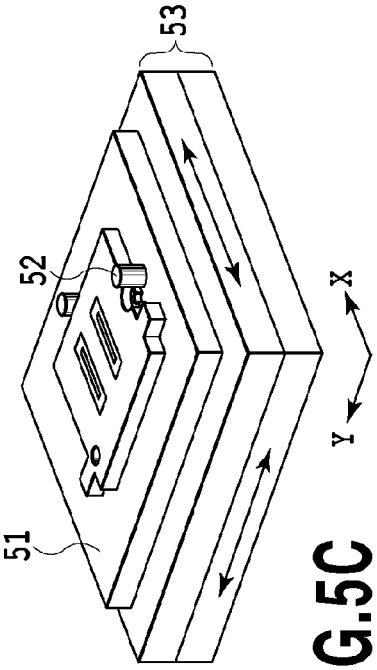


FIG.5C

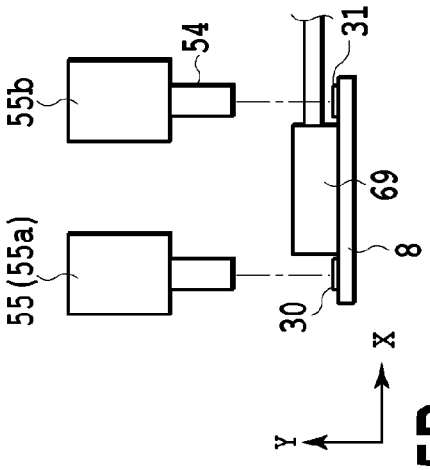


FIG.5D

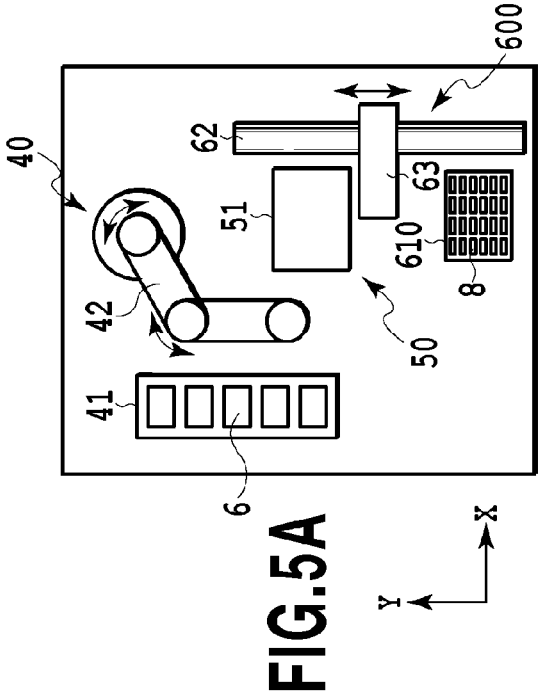


FIG.5A

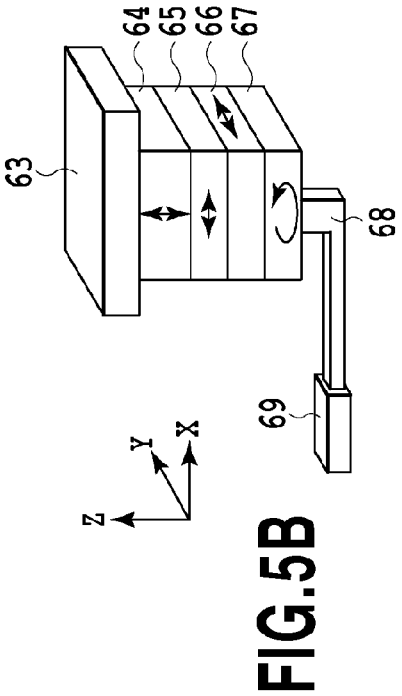


FIG.5B

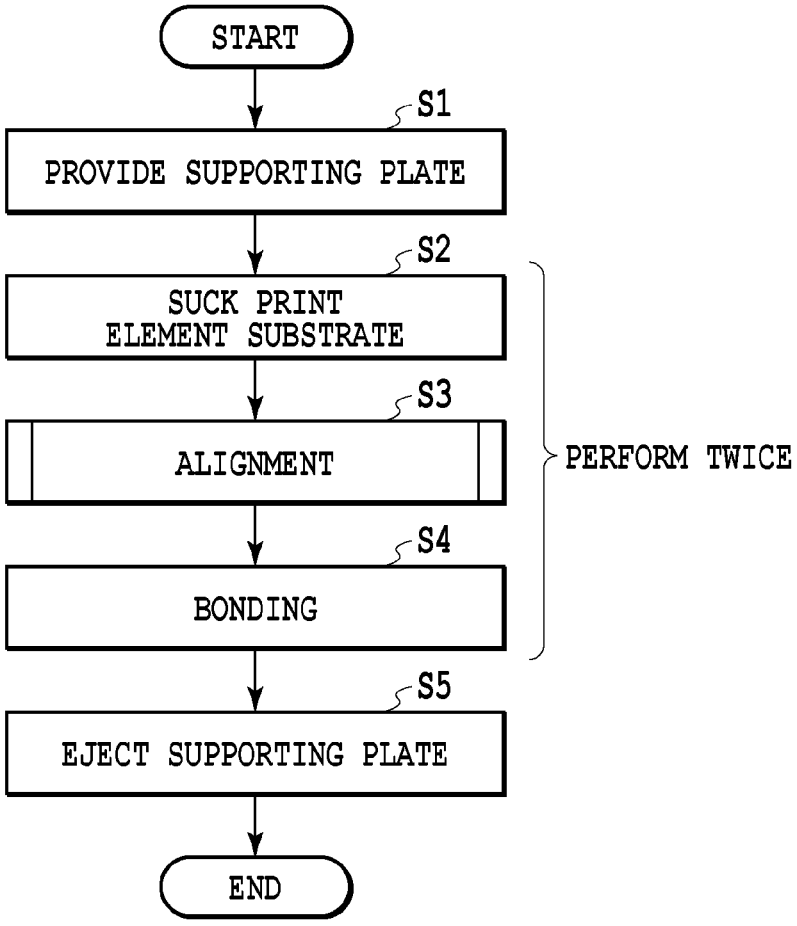

START
S1
PROVIDE SUPPORTING PLATE
S2
SUCK PRINT ELEMENT SUBSTRATE
S3
ALIGNMENT
S4
BONDING
PERFORM TWICE
S5
EJECT SUPPORTING PLATE
END

FIG.6

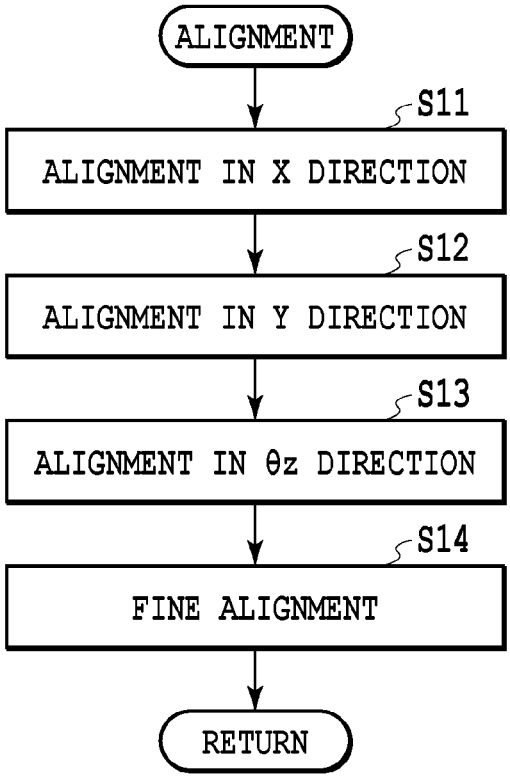

ALIGNMENT
S11
ALIGNMENT IN X DIRECTION
S12
ALIGNMENT IN Y DIRECTION
S13
ALIGNMENT IN θz DIRECTION
S14
FINE ALIGNMENT
RETURN

FIG.7

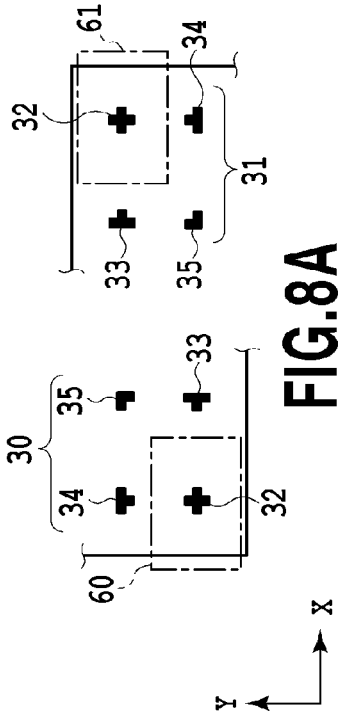


FIG.8A

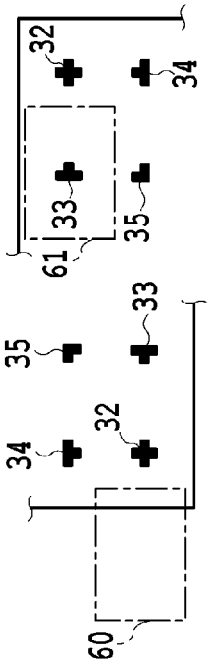


FIG.8B

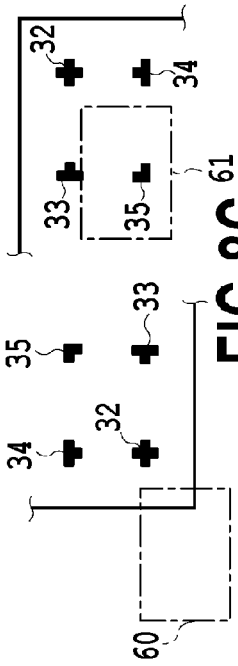


FIG.8C

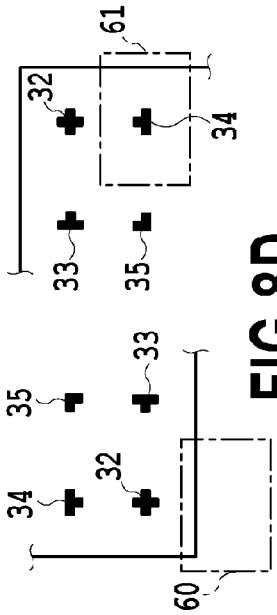


FIG.8D

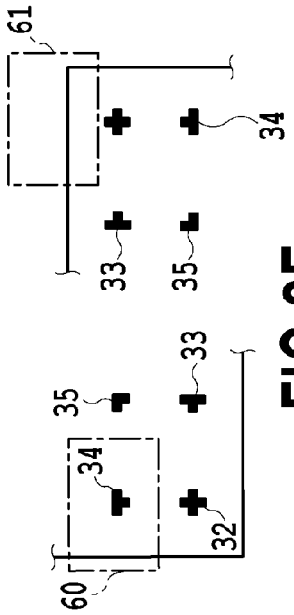


FIG.8E

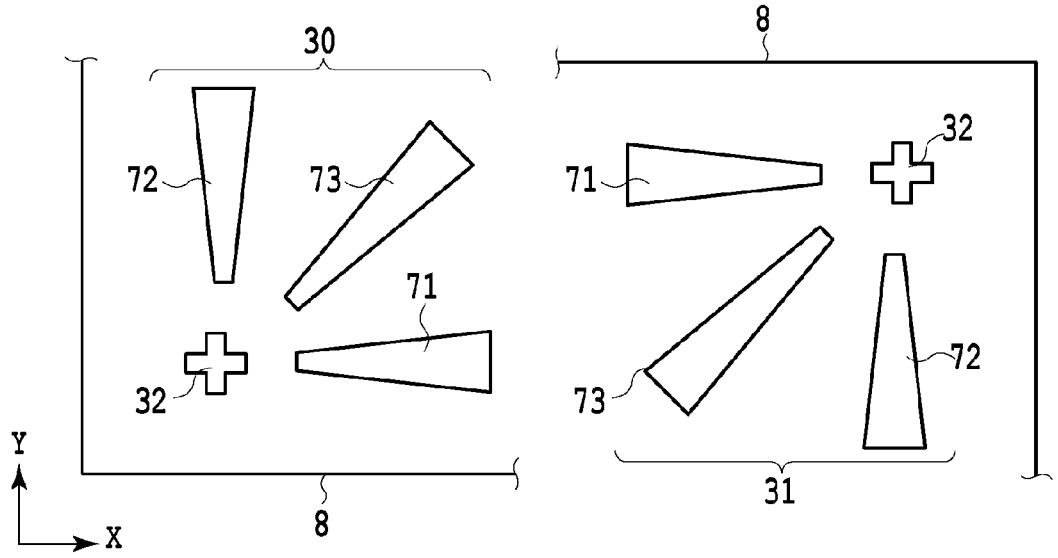


FIG.9A

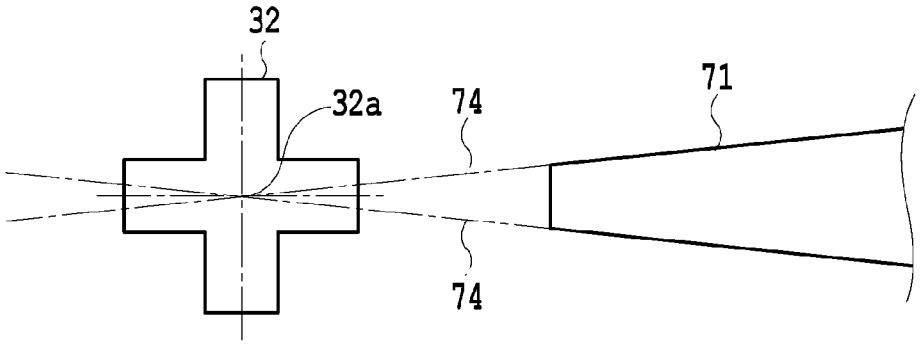


FIG.9B

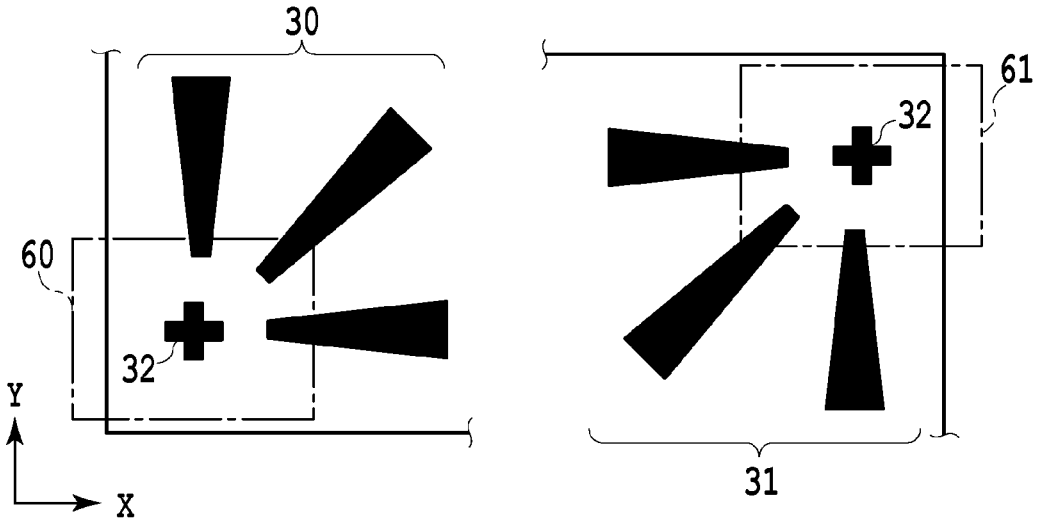


FIG.10A

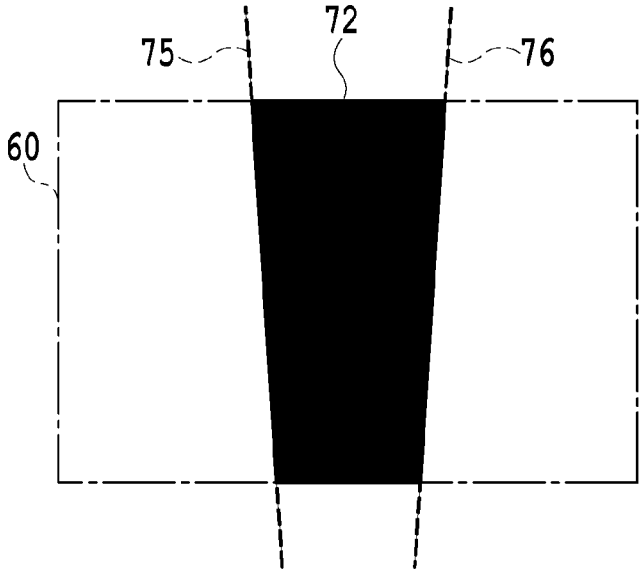


FIG.10B

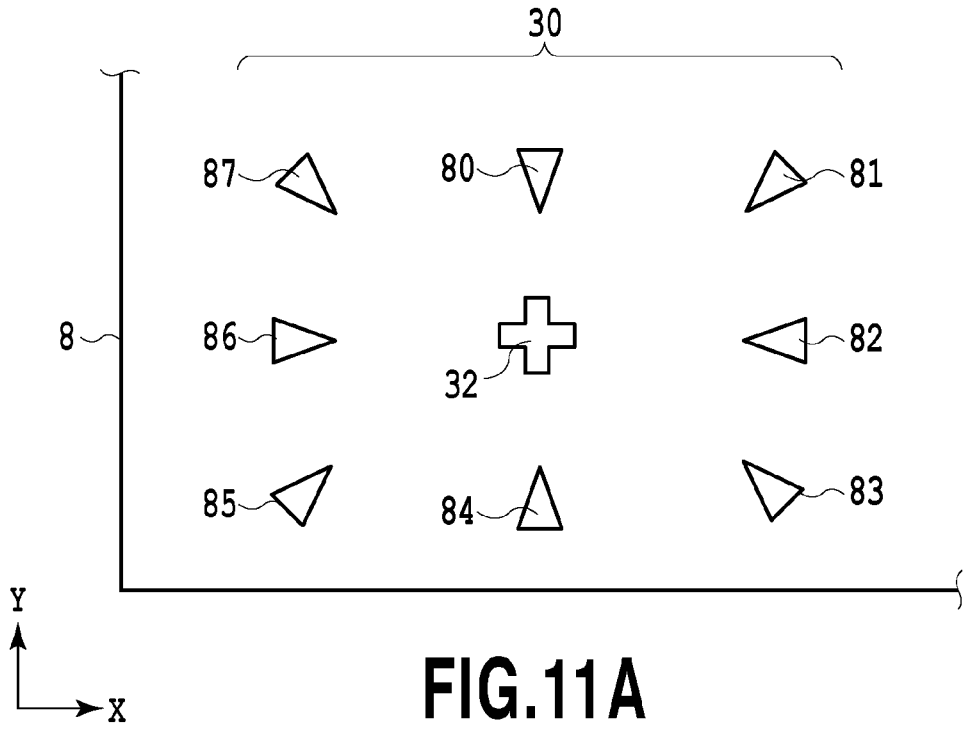


FIG.11A

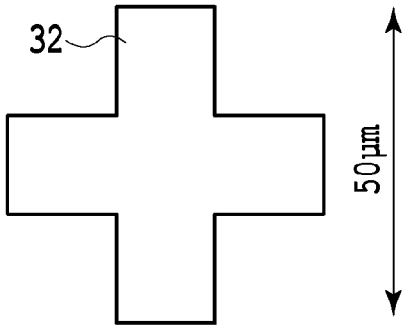


FIG.11B

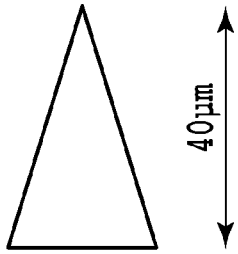


FIG.11C

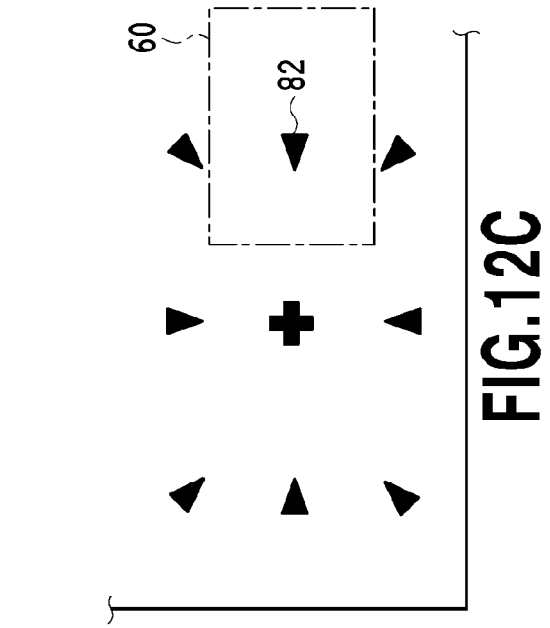


FIG.12C

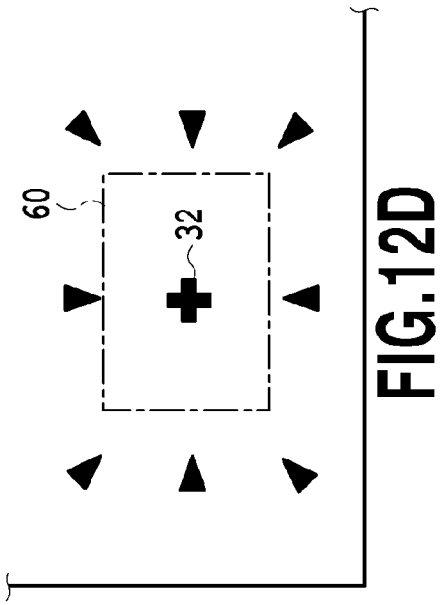


FIG.12D

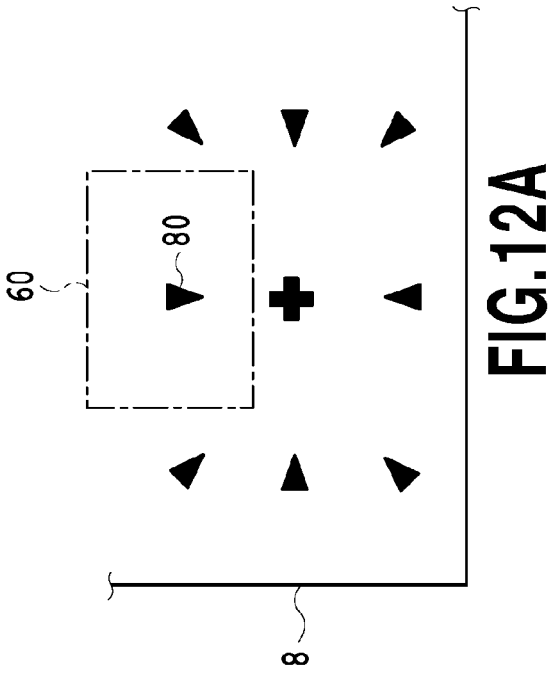


FIG.12A

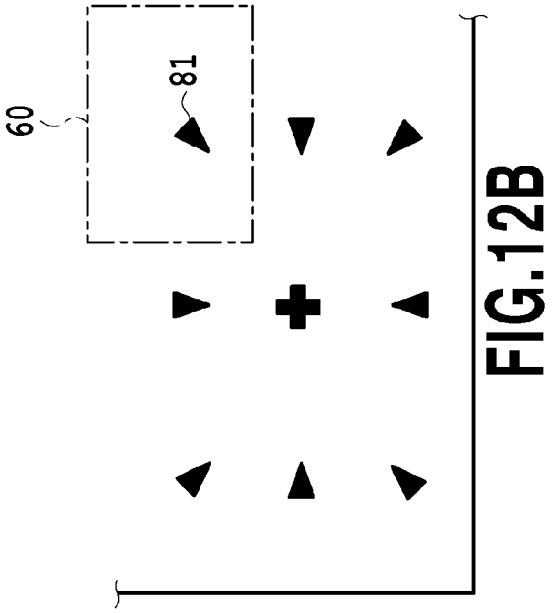


FIG.12B

LIQUID EJECTION HEAD AND METHOD FOR FABRICATING THE SAME

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a liquid ejection head applied to a printing apparatus that ejects liquid such as ink to perform printing and to a method for fabricating the same.

2. Description of the Related Art

Liquid ejection printing apparatuses (hereinafter also simply referred to as printing apparatuses) are widely used as output devices or the like for computers and a wide variety of printing apparatuses are being produced on a commercial basis. Printing methods for such printing apparatuses include a method that uses an electrothermal transducer as an ejection energy generator. A liquid ejection head built in a printing apparatus that uses the method has an electrothermal transducer provided in a pressurizing chamber of a print element substrate and an electrical pulse which serves as an ejection signal is applied to the transducer to provide thermal energy to liquid such as ink, and uses bubble pressure generated in boiling of the liquid to eject the liquid.

In a liquid ejection head used for such a liquid ejection printing apparatus, a plurality of print element substrates is arrayed and bonded to a base plate. In order to precisely dispose the respective print element substrates, reference marks are provided on the print element substrates and the reference marks are optically photographed and recognized for alignment. In the alignment, the print element substrate is sucked onto a vacuum finger (hereinafter also simply referred to as a finger) and photographed from above with two CCD cameras. The reference mark includes a circular portion and four rectangular portions, all of which are used as one mark.

While increasing a photographing magnification ratio of the optical system is effective for more accurately disposing the plurality of print element substrates, the increase of the photographing magnification ratio could cause the following problems.

In the case where the photographing magnification ratio of the optical system is increased in order to perform more accurate alignment, the photographing region becomes narrow accordingly. Furthermore, variations in the outside dimensions of the print element substrates and variations in stop precision of the print element substrate transport system before the print element substrates are sucked onto the finger cause variations also in the relative positional relationship between the finger and the reference marks provided on the print element substrates.

For this reason, in the case where the photographing region narrows at the first photographing after a print element substrate is sucked onto the finger, a reference mark does not exist in the photographing region, which may disable alignment of the print element substrate.

Furthermore, even in the case where the photographing magnification ratio is increased and the rectangular portions of the reference mark are included in the photographing region, it takes long time to perform alignment of the print element substrate because the direction in which the circular portion of the reference mark exists cannot be known.

While a conventional technique such as the one described in Japanese Patent Laid-Open No. 2002-79676 sufficiently satisfied the image quality requirements in the past, more accurate alignment becomes necessary in order to satisfy the image quality demanded now and in the future.

SUMMARY OF THE INVENTION

In light of the problems stated above, an object of the present invention is to provide a liquid ejection head that can reduce trouble in alignment of a print element substrate even in the case where a high magnification optical system is used and a method for fabricating the same.

To achieve the object, a liquid ejection head of the present invention which includes a print element substrate for ejecting liquid includes at least one reference mark which is provided on the print element substrate and used as a reference in alignment of the print element substrate, and an auxiliary mark which is provided on the print element substrate corresponding to the reference mark and includes information indicating a relative position with respect to the reference mark.

According to the present invention, a liquid ejection head includes a reference mark and an auxiliary mark indicating a relative position of the reference mark and thereby can reduce trouble in alignment of a print element substrate even in the case where a high magnification optical system is used.

Further features of the present invention will become apparent from the following description of exemplary embodiments (with reference to the attached drawings).

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of a liquid ejection head;

FIG. **2**A is a perspective view of a print element unit;

FIG. **2**B is a perspective view of the print element unit;

FIG. **3**A is an external perspective view of a print element substrate;

FIG. **3**B is a cross-sectional view of the print element substrate;

FIG. **4**A is an enlarged view of a mark part and its periphery formed on the print element substrate;

FIG. **4**B is an enlarged view of a mark part and its periphery formed on the print element substrate;

FIG. **5**A is a diagram illustrating a mounter;

FIG. **5**B is a diagram illustrating the mounter;

FIG. **5**C is a diagram illustrating the mounter;

FIG. **5**D is a diagram illustrating the mounter;

FIG. **6** is a flowchart illustrating a process for bonding the print element substrate to a supporting plate;

FIG. **7** is a flowchart illustrating an alignment operation;

FIG. **8**A is a diagram illustrating images photographed by a camera;

FIG. **8**B is a diagram illustrating images photographed by the camera;

FIG. **8**C is a diagram illustrating images photographed by the camera;

FIG. **8**D is a diagram illustrating images photographed by the camera;

FIG. **8**E is a diagram illustrating images photographed by the camera;

FIG. **9**A is an enlarged view of a mark part and its periphery on the print element substrate;

FIG. **9**B is an enlarged view of a region of the mark part and its periphery on the print element substrate;

FIG. **10**A is a schematic diagram of photographed images during alignment;

FIG. **10**B is a schematic diagram of photographed images during alignment;

FIG. **11**A is an enlarged view illustrating a mark part and its periphery on the print element substrate;

FIG. **11**B is an enlarged view illustrating a mark part and its periphery on the print element substrate;

FIG. **11**C is an enlarged view illustrating a mark part and its periphery on the print element substrate;

FIG. **12**A is a schematic diagram of a photographed image during alignment;

FIG. **12**B is a schematic diagram of a photographed image during alignment;

FIG. **12**C is a schematic diagram of a photographed image during alignment; and

FIG. **12**D is a schematic diagram of a photographed image during alignment.

DESCRIPTION OF THE EMBODIMENTS

First Embodiment

A first embodiment of the present invention will be described below with reference to drawings.

FIG. **1** is a perspective view of a liquid ejection head (hereinafter also referred to as the print head) ejecting liquid such as ink in the present embodiment; FIGS. **2**A and **2**B are perspective views of a print element unit constituting the print head. A print head **1** includes a tank holder **3** containing a plurality of ink tanks **4** and a print element unit **2** attached to the tank holder **3**.

As illustrated In FIG. **2**A, the print element unit **2** includes an auxiliary plate **7**, two print element substrates **8**, and an electric wiring plate **9** which are bonded to a supporting plate **6** in which ink supply ports **5** are formed. After completion of the bonding of these components, the print element unit **2** appears as illustrated in FIG. **2**B. Reference numeral **10** in FIG. **2**B indicates sealant applied for protecting a portion which electrically connects an electrical connection part (not illustrated) of the electric wiring plate **9** and an electrical connection part (not illustrated) of the print element substrates **8**.

Note that while two print element substrates **8** that are identical in geometry are mounted in the print element unit **2** in FIGS. **2**A and **2**B, the print head may mount print element substrates having different geometries and the number of print element substrates **8** is not limited to two, but may be one or three or more.

Subsequently, the print element substrate will now be described with reference to FIGS. **3**A and **3**B. FIG. **3**A is an external perspective view of the print element substrate and FIG. **3**B is a schematic cross-sectional view illustrating IIIB-IIIB cross-section of FIG. **3**A. The print element substrate **8** includes a silicon substrate **20** and an ink supply port **21** which passes through the silicon substrate **20** from the obverse side to the reverse side thereof is provided in the center of the silicon substrate **20**. A plurality of electrothermal transducers **22**, which generates energy used for ejecting liquid, is disposed on the obverse side and bubble generation chambers **23** and ejection ports **24** are formed from a material such as resin so as to correspond to the electrothermal transducers **22**.

Furthermore, mark parts **30** and **31** used for alignment in bonding the print element substrate **8** to the supporting plate **6** are formed at ends of the print element substrate **8**. Note that a large number of the print element substrates **8** are formed on a substantially circular 8-inch sized silicon wafer and the silicon wafer is diced into individual print element substrates **8** with a dicing machine.

The mark parts **30** and **31** will now be described. FIGS. **4**A and **4**B are enlarged views of mark parts and their peripheries formed on the print element substrate; FIG. **4**A is an enlarged view of the mark part **30** and its periphery and FIG. **4**B is an enlarged view of the mark part **31** and its periphery. A reference mark **32** serves as a mark for alignment in bonding the print element substrate **8** to the supporting plate **6**, and the reference mark **32** is photographed and recognized by an optical system, which will be described later. One or more auxiliary marks **33** to **35** are provided adjacent to one reference mark and indicate the relative positions with respect to the reference mark **32**.

The auxiliary marks **33**, **34**, and **35** are disposed at positions predetermined distances away from the reference mark **32** in an arrow X direction, in an arrow Y direction, and in both of the arrow X direction and the arrow Y direction, respectively. The predetermined distances will be described later together with the description of the optical system.

The reference mark **32** and the auxiliary marks **33** to **35** are disposed in a matrix as illustrated in the figures and the auxiliary marks **33** to **35** are disposed so as to surround the reference mark **32**. The reference mark **32** and the auxiliary marks **33** to **35** are formed by depositing an aluminum material. Note that while the reference mark **32** and the auxiliary marks **33** to **35** are formed on the same plane in the present embodiment, all or some of the auxiliary marks may be formed from resin or other material as with formation of the ejection ports **24**.

In that case, however, an image of the mark part photographed during alignment, which will be described later, will be somewhat out of focus because there is a difference in height between the reference mark **32** and the auxiliary marks formed from resin. Therefore, preferably the respective marks are formed on the same plane.

Next, a machine that is used in fabrication of the liquid ejection head for bonding the print element substrates **8** to the supporting plate (hereinafter the machine will be also referred to as a mounter) will be described with reference to FIGS. **5**A to **5**D. FIG. **5**A is a plan view schematically illustrating a configuration of the mounter, which mainly includes a supporting plate transport unit **40**, a supporting plate fixing unit **50**, and a substrate transport unit **600**. A plurality of supporting plates **6** before bonding is arrayed in a supporting plate tray **41** and transferred one by one from the supporting plate tray **41** onto a supporting plate fixing jig **51** by a supporting plate transport robot **42**.

Note that while the supporting plates **6** are arrayed in the supporting plate tray **41** with an adhesive applied beforehand to the supporting plates **6** in the present embodiment, the adhesive may be applied in the mounter. FIG. **5**B is a diagram illustrating the supporting plate fixing unit **50**. The supporting plate fixing unit **50** includes an XY-stage **53** on which the supporting plate fixing jig **51** is attached, and is configured to fix a supporting plate by abutting the supporting plate against pins **52**. FIG. **5**C is a diagram illustrating the substrate transport unit **600**.

The substrate transport unit **600** includes a substrate transport robot **62** with a movable table **63** which reciprocates between the supporting plate fixing unit **50** and above the substrate tray **610** and on which a Z-stage **64**, an X-stage **65**, a Y-stage **66**, and a θz-stage **67** are mounted in this order from the top. An arm **68** is attached to the θz-stage **67** and a finger **69** which sucks and holds the print element substrate **8** is attached at the tip of the arm **68**. The print element substrates **8** are arrayed in the substrate tray **610** and are one by one sucked onto and held by the finger **69** and transported to above the supporting plate fixing jig **51**.

FIG. **5**D is a diagram illustrating lenses **54** and cameras **55** above the supporting plate fixing jig **51**. Two sets of lens **54** and camera **55** for photographing the mark parts **30** and **31** formed on the print element substrate **8** sucked onto and held by the finger **69** are placed above the supporting plate fixing jig **51**. The positions where cameras **55***a* and **55***b* are placed are accurately adjusted so that the print element substrate is placed at the position where the print element substrate is to

be bonded to the supporting plate **6** in the case where each reference mark **32** is reflected in the center of each of the cameras **55***a* and **55***b*.

Moreover, in order to achieve highly accurate alignment, according to the specification of the optical system, the camera **55** includes a photographing element having a cell size of 7.4 μm square, and has 656 effective pixels in the arrow X direction and 492 effective pixels in the arrow Y direction. The lens **54** built in the camera **55** mounts a lens capable of magnifying by 6 times. In this specification, a photographing resolution is approximately 1.23 μm per pixel in both of the arrow X direction and the arrow Y direction, which enables highly accurate alignment. The size of a photographing region is approximately 0.8 mm in the arrow X direction and approximately 0.6 mm in the arrow Y direction.

The positional relationships between the reference mark **32** and the auxiliary marks **33** to **35** in each of the mark parts **30** and **31** of the print element substrate **8** will now be described with reference to FIGS. **4**A and **4**B. The center of the reference mark **32** is 0.6 mm away from the center of the auxiliary mark **33** in the arrow X direction. Similarly, the auxiliary mark **34** is 0.6 mm away from the auxiliary mark **35** in the arrow X direction, and the reference mark **32** is 0.4 mm away from the auxiliary mark **34** in the arrow Y direction. With respect to the auxiliary marks **33** and **34**, the reference mark **32** is provided in a direction of protrusion of each of the auxiliary marks **33** and **34**; with respect to the auxiliary mark **35**, the reference mark **32** is provided in a direction of the rectangularly cut portion (oblique direction). This means that the auxiliary marks include information indicating the relative positions with respect to the reference mark.

With such positional relationships, in a case of photographing the mark parts **30** and **31** with the optical system according to the previously described specification, at least one of the reference mark **32** and the auxiliary marks **33** to **35** is photographed in the photographed image of at least one of the cameras **55***a* and **55***b*.

FIG. **6** is a flowchart illustrating a process for bonding the print element substrate **8** to the supporting plate **6**. The process for bonding the print element substrate **8** to the supporting plate **6** will be described below with reference to the flowchart. In the case where the process for bonding the print element substrate **8** to the supporting plate **6** is started, one of the supporting plates **6** arrayed in the supporting plate tray **41** is picked up and mounted on the supporting plate fixing jig **51** by the supporting plate transport robot **42** at step S**1**. Then, at step S**2**, the substrate transport robot **62** is activated to move the movable table **63** to above the substrate tray **61** and the print element substrate **8** is sucked onto and held by the finger **69**.

Then, alignment of the print element substrate **8** is performed at step S**3**. A detailed description of step S**3** will be separately provided later. Then, at step S**4**, the Z-stage **64** is lowered to bond the print element substrate **8** to the supporting plate **6**. Since the print head of the present embodiment includes two print element substrates **8**, step S**2** to step S**4** are performed twice.

Note that before bonding of the second print element substrate **8**, the XY-stage **53** of the supporting plate fixing unit **50** is activated to move the supporting plate **6** so as to bond the second print element substrate **8** to a predetermined position. Lastly, at step S**5**, the supporting plate **6** after completion of the bonding is ejected into the supporting plate tray **41** by the supporting plate transport robot **42** to complete the process.

FIG. **7** is a flowchart illustrating the alignment operation at step S**3** of FIG. **6**. FIGS. **8**A to **8**E are schematic diagrams illustrating images photographed by the cameras **55***a* and **55***b* during alignment. Details of the alignment operation at step S**3** of FIG. **6** will now be described with reference to FIG. **7** and FIGS. **8**A to **8**E.

In FIGS. **8**A to **8**E, photographed images **60** indicated by dashed boxes represent images photographed with the camera **55***a* and photographed images **61** indicated by dashed boxes represent images photographed with the camera **55***b*. FIG. **8**A illustrates a state after completion of the entire process in the flowchart of FIG. **7**, in which the position of the print element substrate **8** is adjusted so that the reference mark **32** in the mark part **30** is reflected substantially in the center of the photographed image **60** and the reference mark **32** in the mark part **31** is reflected substantially in the center of the photographed image **61**.

Note that the geometries of the marks **32** to **35** have been pattern-registered in an unillustrated image processing apparatus beforehand and a pattern searching function of the image processing apparatus is used to detect and recognize which mark exists and where in a photographed image.

Upon start of the alignment, first at step S**11**, the position of the print element substrate **6** is adjusted in the arrow X direction. FIG. **8**B illustrates one example of a state where the mark parts **30** and **31** are photographed for the first time. FIG. **8**B represents an exemplary state in which the print element substrate **8** is deviated to the right and therefore none of the reference mark **32** and the auxiliary marks **33** to **35** are photographed in the photographed image **60**, whereas the auxiliary mark **33** is reflected in the photographed image **61**.

This phenomenon is due to the relative positional relationship in the case where the print element substrate **8** is sucked onto and held by the finger **69** and the cause thereof can be cited as follows. As has been descried earlier, the print element substrate **8** has been diced from a silicon wafer and there are variations in outside dimensions of individual print element substrates **8** due to the precision of the dicing.

Accordingly, there are variations in the positions of the print element substrates **8** in the substrate tray **61** in the case where the print element substrates **8** are placed in the substrate tray **61**, resulting in variations in the relative positions of the print element substrates **8** and the finger **69**. Since the amounts of the variations can be somewhat greater than the photographing region of the optical system, the phenomenon that the reference mark **32** is not reflected in the photographed image **60** or **61** may occur.

FIG. **8**C illustrates a state where the print element substrate **8** is deviated also upward in addition to the right and, in this case, the auxiliary mark **35** is reflected in the photographed image **61**. In the case as illustrated in FIG. **8**B or **8**C, the X-stage **65** is controlled so as to move the print element substrate **8** leftward, thereby allowing the reference mark **32** or the auxiliary mark **34** to be reflected in the photographed image **61**. Note that while the case where the print element substrate **8** is deviated to the right is described above, in the case of leftward deviation, in a manner opposite to the above, the reference mark **32** or the auxiliary mark **34** is allowed to be reflected in the photographed image **60**.

Then, at step S**12**, the print element substrate **8** is moved in the Y direction. FIG. **8**D illustrates a state where the auxiliary mark **34** is reflected in the photographed image **61**, and in this case, the Y-stage **66** is controlled to move the print element substrate **8** downward so as to allow the reference mark **32** to be reflected in the photographed image **61**. In contrast, in the case where the auxiliary mark **34** is reflected in the photographed image **60** as in FIG. **8**E, the Y-stage **66** is moved upward so as to allow the reference mark **32** to be reflected in the photographed image **60**.

Then, adjustments in the rotational (θz) directions are made at step S13: the θz-stage **67** is adjusted so as to allow the reference mark **32** to be reflected in both of the photographed images **60** and **61**. Lastly, fine adjustments of the stages **65** to **67** are made at step S14 so that each reference mark **32** is reflected in the center of each of the photographed images **60** and **61** as illustrated in FIG. **8**A, thereby completing the alignment.

Thus, a liquid ejection head can be realized that can reduce trouble in alignment of a print element substrate by detecting and recognizing auxiliary marks without an interruption of the alignment operation even in the case where a reference mark is not reflected in cameras at the first photographing.

Second Embodiment

A second embodiment of the present invention will be described below with reference to drawings. Note that the basic configuration of the present embodiment is the same as that of the first embodiment and therefore only the characteristic configuration will be described below.

While the geometries of the auxiliary marks are pattern-registered in the image processing apparatus and individual patterns are searched for in the first embodiment, an example will be described in the present embodiment in which pattern registration of and pattern searching for auxiliary marks are not performed will be described. The configuration of the present embodiment differs from that of the first embodiment as auxiliary marks in mark parts **30** and **31** on print element substrates **8**.

FIG. **9**A is an enlarged view of mark parts and their peripheries on a print element substrate **8** in the present embodiment; auxiliary marks **71** to **73** have the same trapezoidal geometry but differ in orientation. FIG. **9**B is an enlarged view of a reference mark **32** and a portion of the auxiliary mark **71**; the inclinations of the oblique sides of the trapezoidal geometry of the auxiliary mark **71** are such that an intersection of imaginary lines **74** extended from the two oblique sides coincides with the center **32***a* of the reference mark **32**.

Alignment of the present embodiment will now be described. FIGS. **10**A and **10**B are schematic diagrams of photographed images during alignment. Upon completion of the alignment, each reference mark **32** is reflected in each of the photographed images **60** and **61** as illustrated in FIG. **10**A. FIG. **10**B illustrates one example of a photographed image photographed first and a portion of the auxiliary mark **72** (a partial image) is reflected in the photographed image **60**.

In such a case, an edge detection function of an image processing apparatus for detecting contrast differences is used to detect the oblique sides of the auxiliary mark **72** as illustrated in FIG. **10**B and the position of an intersection where extension lines **75** and **76** of the oblique sides intersect is calculated. Since the position of the intersection coincides with the center of the reference mark **32** as noted previously, the amount of movement of each of the stages **65** to **67** can be obtained, which allows prompt alignment.

While the case where a portion of the auxiliary mark **72** is reflected in the photographed image is described in the example described above, the position of the reference mark **32** can be obtained similarly by calculating an intersection of extension lines of the oblique sides in the case where a portion of another auxiliary mark **71** or **73** is reflected in a photographed image.

Thus, a liquid ejection head can be realized that can reduce trouble in alignment of a print element substrate because the position of a reference mark can be identified by detecting the inclinations of the oblique sides of an auxiliary mark even in the case where a reference mark is not reflected in cameras at the first photographing.

Third Embodiment

A third embodiment of the present invention will be described below with reference to drawings. Note that the basic configuration of the present embodiment is the same as that of the first embodiment and therefore only the characteristic configuration will be described below.

While examples in which two mark parts exist on a print element substrate have been described in the first and second embodiments, an example will be described in the present embodiment in which only one mark part exists. The configuration of the present embodiment is the same as that of the first embodiment, except that only a mark part **30** exists on a print element substrate **8** and that a different alignment method is used.

FIG. **11**A is an enlarged view of a mark part **30** and its periphery of a print element substrate **8** of the third embodiment; as indicated by **80** to **87**, auxiliary marks have the same isosceles triangular geometry but all of them differ from one another in orientation. Each of the auxiliary marks **80** to **87** is formed so that a vertex angle (the angle between the equal sides) of the isosceles triangle points to the reference mark **32**. As illustrated in FIGS. **11**B and **11**C, the outermost size of the reference mark **32** is 50 μm in both of the X and Y directions and each of the auxiliary marks **80** to **87** has a base of 30 μm and a height of 40 μm.

Moreover, the distance between the reference mark **32** and each of the auxiliary marks **80** to **87** is uniformly 0.7 mm in the X direction and 0.5 mm in the Y direction and these nine marks are formed in a substantially matrix pattern. Note that the distances between the marks are the distances from the center of the reference mark **32** to the vertex of each of the auxiliary marks **80** to **87**. The mark sizes and the positional relationships allow at least one of the reference mark **32** and the auxiliary marks **80** to **87** to be photographed in the case where the mark part **30** is photographed.

In the present embodiment, both of the geometry of the reference mark **32** and the isosceles triangular geometry of each of the auxiliary marks **80** to **87** are pattern-registered beforehand in an image processing apparatus and both of the patterns are pattern-searched in a photographed image. The searching performed here is searching capable of detecting any of the registered geometries reflected in any orientation in a photographed image and also capable of providing the orientation of a detected pattern as a result of the searching.

Alignment of the present embodiment will now be described with reference to FIGS. **12**A to **12**D, which are schematic diagrams of photographed images during alignment. FIG. **12**A illustrates one example of a photographed image in the case where the mark part **30** has been photographed for the first time and the auxiliary mark **80** is reflected in the photographed image **60**. Since it can be recognized from the result of the pattern searching that the vertex of the auxiliary mark **80** points downward in the figure in this case, it is possible to reflect the reference mark **32** by moving the print element substrate **8** upward by one field of view.

Furthermore, in the case where the auxiliary mark **82** is detected as illustrated in FIG. **12**B, the reference mark **32** is allowed to be reflected by moving the print element substrate **8** rightward and upward by one field of view; in the case where the auxiliary mark **81** is detected as illustrated in FIG. **12**C, the reference mark **32** is allowed to be reflected by moving the print element substrate **8** rightward by one field of

view. After the reference mark **32** has been detected, fine adjustments of the position of the print element substrate **8** are made so that the reference mark **32** is reflected substantially in the center of the photographed image **60** as illustrated in FIG. **12**D.

While the cases where the auxiliary marks **80**, **81** and **82** are reflected in a photographed image have been described in the example given above, the direction in which the print element substrate **8** is to be moved can be similarly determined from the orientation of the vertex of the isosceles triangle in the case where any of the other auxiliary marks **83** to **87** are reflected in a photographed image.

Thus, a liquid ejection head can be realized that can reduce trouble in alignment of a print element substrate because the position of a reference mark can be identified by detecting the orientation of the vertex of an auxiliary mark even in the case where a reference mark is not reflected in cameras at the first photographing.

While the present invention has been described with reference to exemplary embodiments, it is to be understood that the invention is not limited to the disclosed exemplary embodiments. The scope of the following claims is to be accorded the broadest interpretation so as to encompass all such modifications and equivalent structures and functions.

This application claims the benefit of Japanese Patent Application No. 2013-098790, filed May 8, 2013, which is hereby incorporated by reference herein in its entirety.

What is claimed is:

1. A liquid ejection head having a print element substrate for ejecting liquid, comprising:

at least one reference mark provided on the print element substrate and used as a reference in alignment of the print element substrate; and

an auxiliary mark provided on the print element substrate corresponding to the reference mark and including information indicating a relative position with respect to the reference mark,

wherein the reference mark and the auxiliary mark differ in geometry.

2. The liquid ejection head according to claim **1**, wherein one or more of the auxiliary marks are provided per the reference mark.

3. The liquid ejection head according to claim **1**, wherein the auxiliary mark has a trapezoidal geometry.

4. The liquid ejection head according to claim **3**, wherein the reference mark is positioned at an intersection of two imaginary lines extended from oblique sides of the auxiliary mark having the trapezoidal geometry.

5. The liquid ejection head according to claim **1**, wherein the auxiliary mark has an isosceles triangular geometry.

6. The liquid ejection head according to claim **5**, wherein the reference mark is positioned in a direction pointed by a vertex angle of the auxiliary mark having the isosceles triangular geometry.

7. The liquid ejection head according to claim **1**, wherein the reference mark and the auxiliary mark are arranged in a matrix.

8. The liquid ejection head according to claim **1**, wherein a plurality of elements generating energy used for ejecting liquid is formed on the print element substrate.

9. A liquid ejection head having a print element substrate for ejecting liquid, comprising:

at least one reference mark provided on the print element substrate and used as a reference in alignment of the print element substrate; and

a plurality of auxiliary marks provided on the print element substrate corresponding to the reference mark and including information indicating a relative position with respect to the reference mark, wherein the plurality of the auxiliary marks differ from one another in geometry or orientation.

10. The liquid ejection head according to claim **9**, wherein each of the auxiliary marks has a trapezoidal geometry.

11. The liquid ejection head according to claim **10**, wherein the reference mark is positioned at an intersection of two imaginary lines extended from oblique sides of each of the auxiliary marks having the trapezoidal geometry.

12. The liquid ejection head according to claim **9**, wherein each of the auxiliary marks has an isosceles triangular geometry.

13. The liquid ejection head according to claim **12**, wherein the reference mark is positioned in a direction pointed by a vertex angle of each of the auxiliary marks having the isosceles triangular geometry.

14. The liquid ejection head according to claim **9**, wherein the reference mark and the auxiliary marks are arranged in a matrix.

15. The liquid ejection head according to claim **9**, wherein a plurality of elements generating energy used for ejecting liquid is formed on the print element substrate.

16. A method for fabricating a liquid ejection head mounting a print element substrate for ejecting liquid, in a predetermined position on a supporting plate, comprising the steps of:

photographing a reference mark provided on the print element substrate or an auxiliary mark provided in the vicinity of the reference mark;

detecting the reference mark or the auxiliary mark from the photographed image; and

identifying a position of the reference mark from the detected auxiliary mark in a case where the reference mark is not detected in the photographed image.

17. The method for fabricating a liquid ejection head according to claim **16**, wherein the step of detecting the reference mark or the auxiliary mark detects the reference mark and the auxiliary mark by pattern searching in which geometries of the respective marks are pattern-registered beforehand.

18. The method for fabricating a liquid ejection head according to claim **16**, wherein the step of identifying the position of the reference mark identifies the position from a geometry or orientation of the auxiliary mark detected.

19. The method for fabricating a liquid ejection head according to claim **16**, wherein the step of identifying the position of the reference mark includes the step of detecting inclination of the auxiliary mark from a photographed partial image of the auxiliary mark.

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